CAMOUFLAGE, THEORY AND PRACTICE: A SUMMARY

by

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FOREWORD

As the war goes on, it becomes ever more clear that the services of people trained in the arts and crafts are an important national resource. Posters, charts, and illustrations have brought to millions the important messages of conservation and the need for all-out co-operation. Other material of this sort is now being prepared for use in winning the cooperation and good-will of people in occupied territories. The armed services have set up a large number of visual education centers where material is produced for service manuals and for instructional purposes. Many buildings in Army camps all over the country have been enlivened with mural paintings and other forms of decoration; the progress of the war is being documented by some of America's leading artists. On the home front, the Museum places its facilities at the disposal of the war effort and for exhibitions dealing with it. It is collecting material for use outside the building in war-time art classes; members of its staff are equipped to lecture and advise on war-time uses of art.

In addition, the Cleveland Museum of Art is issuing, from time to time, pamphlets in a series entitled "Art and War-time Publications of the Department of Education, The Cleveland Museum of Art". The first (now in use in almost 800 institutions throughout the country) was "The Use of Art and Artists in Times of War". The present pamphlet is the second such publication. The museum is proud to be able to use its facilities in behalf of victory in this crisis; it is proud, also, to help to demonstrate that art is not remote from the everyday problems of the people, but can and does serve whenever the need arises.

William M. Milliken, Director
The Cleveland Museum of Art

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Introduction: CAMOUFLAGE AND ART TRAINING

Camouflage might be called the art of deception; how to deceive people and influence friends. The camouflage artist, or engineer, attempts just that: he wants to delay recognition of a vital war plant or a military target just long enough so that an enemy bombardier will be uncertain about its position or identity. Even a brief hesitation may cost the attacker success, for fractional errors in timing are crucial: at 300 miles per hour a plane travels 440 feet in a second, and a miss due to one second's time-error may save the object of attack.

Because of the artifices of the camoufleur, whole raids have been spent on dummy targets. Some of the most notorious targets of the war, such as the Scharnhorst and the Gneisenau, have survived more than one hundred bombing expeditions against them; factories continue to operate and docks to function; thanks to protective concealment measures, many a soldier owes his life to his ability to find effective cover.

The tremendous growth of popular interest in camouflage in the past few months is phenomenal; in it the teacher has what we would call, in street talk, "a natural". It is another one of those fusions of art, science, and technology, of which two have already provided the most popular forms of expression in our time, namely, photography and the movies. Students are fascinated with it, as they are with aviation; and far from requiring stimulation of interest, they demand information and the opportunity to carry out their projects.

This hybrid art, at its best, spans many fields, amongst them art, photography, architecture, biology and nature study, physics, chemistry, psychology and aviation. Obviously, then, thorough training for camouflage is no matter for art classes alone. But equally obviously, camouflage is the manipulation, in one way or another, of visual effects and appeals to vision. And the basic preparation for such manipulation is to be found in the training of perception and the powers of observation such as one should expect in art classes.

Art education still too often places emphasis on the production of certain limited variety of "artistic" objects. Aside from the immediate facility which this gives to hand and eye, it is of limited value to camouflage. What is watned here (as indeed in all art) is a keenness of observation and visual judgment; a sensitivity to qualities of texture, light, line, modeling, color, and to the interactions of these upon one another; a knowledge of compositional procedures and devices; knowledge of the value of distortion either for psychological effect, or for the visual purposes of making the elements in a visual whole cohere or fall apart, according to some specific need. Camouflage design would seem to demand more skill and precision in these matters than commonly goes into works of the other visual arts: in the latter there is the appeal of pleasure and subject-matter, usually, to prejudice us in the direction of the work; while in camouflage, design and sensitivity are scanned by hostile eyes, and a small error, say, in choice of values, may mean disaster to the target.

The history of art is rich in its lessons for the camoufleur: the treatment of forms; of light and shade, of color; organizational devices and methods of attracting and guiding the eye. The primitive arts contain a wealth of suggestions, for many of the designs of costume and body treatment were largely for purposes of protective concealment. (One must always remember: protective

concealment as seen against their natural surroundings, not in a museum case, or reproduced on the white page of a book). Modern art, of course, is tremendously important in this connection, for, in general, it has been very free with appearances, altering and distorting them for all sorts of reasons. Modern architecture and industrial design have emphasized the use of many novel materials and new uses for old and familiar materials; all this is important reference material for the camouflage student, for he will find that resourcefulness and inventiveness with materials are of great importance.

As has been suggested before, the beauty of the subject is its span, encouraging the student to range far beyond his own somewhat restricted interests. He must go to nature, where he will see the most wonderful camouflage, exemplifying every department of the art, the absolute pinnacle of cunning. The chemistry of pigments, or fire-proofing and rust-proofing, may interest him. Problems of construction, maintenance, and cost estimating tie the subject in nicely with mechanical drawing, architecture, mathematics. The making of models, so important in working out camouflage solutions, offers splendid opportunities in woodworking, the various crafts, modeling, and casting. It calls not only for a high order of craftsmanship, but also for independence and resourcefulness in simulating the conditions met with in the field. The importance of photography in camouflage will lead, perhaps, to a new and more mature attitude to his own photographic work. The importance of siting and topography may lead to renewed interest in geography, in surveying, landscaping, or gardening. All of these, in turn, are grist to the camoufleur's mill.

Conversely, the skills and abilities developed in behalf of camouflage must necessarily stand the young artist in good stead, for he will have learned much more about the appearance of the world, and he will feel perfectly free to handle it according to aesthetic needs. Materials and substances, no matter how humble, will have taken on a new significance, and often enough, a beauty not before seen. There will be a new stimulus to imagination and the use of the wits. More grimly, one may point out that a lad, trained in camouflage and protective concealment, his perpetive powers highly developed, may one day owe his life to his ability to catch a small difference in values or a slight movement--these might mean a sniper, or a trap of some sort.

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The notes which follow were originally issued in connection with a lecture for the Engineering, Science, and Management War Training Course, United States Office of Education, under the sponsorship of Case School of Applied Science. The material is stripped down to the barest summary, a fact which will allow much scope for ingenuity and inventiveness on the part of the teacher. A few words of suggestion have been added as a guide to practical camouflage design (under the heading of Camouflage Maxims); the material on blackout and the bibliography are newly added. The whole is directed toward civilian, rather than military use.

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SECTION ONE: ATTACK AND VULNERABILITY

I. WHAT IS PROTECTIVE CONCEALMENT; CAMOUFLAGE?

Attempt by many now to substitute term "protective concealment" for old term "camouflage"; latter is often associated in the public mind with dazzle-painting, bizarre Rube Goldberg constructions, etc. Actually "protective concealment" today involves many techniques not associated formerly with the word "camouflage." The word "camouflage" comes from the French, and was used there originally to denote fakery or deceit.

This outline will use the terms "protective concealment" and "camouflage" interchangeably.

Sample definitions of camouflage: "...science of confusing the identity of an object for the purpose of deceiving the observer."

"...any type of visual deception, either direct or indirect, which makes it harder for the enemy to find his target."

In short, any device or activity which, regardless of the manner, makes it harder to find the target, or to arrive at an accurate judgment of its nature.

For our purpose, this may be described as accomplished through:

(1) Reduction of visibility (making it hard to see the target).

(2) Changing the appearance of the object (changing its pattern, shape, shadows, color, form, texture, etc.).

(3) Changing the apparent identity of the object (making it look like something else).

(4) Complete concealment (underground or in the side of a hill).

(5) The use of dummies and decoys (to take attention elsewhere).

It is an attempt to outwit the enemy; the Trogan horse is an example; Shakespeare describes camouflage activity in "Macbeth":

"Let every soldier hew him down a bough
And bear't before him: thereby shall we shadow
The numbers of our host and make discovery
Err in report of us."

Kipling's "How the Leopard Got his Spots" is an excellent statement of certain basic principles.

Nature is the master camoufleur; many animals, bugs, birds, fishes, etc., being perfect examples of protective concealment. (See the book, "Adaptive Coloration in Animals," by Hugh Cott.)

Military and civilian camouflage (the latter called "back-area", "rear-area", or "large-area") are based on the same principles, but

in actual practice there are many points of difference: scale, previous reconnaissance, background, permanence, discipline, etc. In military, it may also mean false noises to divert attention; false thrusts or feints, fake gun flashes, fake signs of great activity, fake clues as to number or intention.

Camouflage is probably as old as warfare. Savages are very skilled in body treatment, in concealment by using natural cover (for example, the American Indian), in mimicry. Daniel Boone's garments were ideal for waar in the primeval American forests. During the Revolution the "Red-coats" paid dearly because they insisted on wearing their parade-type of uniform, fighting in parade order, whereas the Minute-men imitated the covered style of the Indians.

Americans must become more serious about protective concealment, both in the field and at home, especially in vulnerable areas. We are apt to "kid" about camouflage and "screw-ball" ideas; but many an American boy may be losing his life in the field because he is negligent about protective concealment; and we know that a large percentage of the bombs dropped fall on dummies, and away from camouflaged installations. Great quantities of the enemy's bombs, fuel, personnel, equipment, are wasted, sometimes whole raids exhausting themselves on "phonies."

The European countries are now spending enormous sums of money on various types of camouflage. It is nothing but a form of insurance--a kind of gamble against averages and probabilities.

The main types of camouflage procedure to be discussed here are:

1. Tone-down
2. Disruptive camouflage
3. Dummies and Decoys
4. Dispersal
5. Complete concealment
6. Blackout
7. Light camouflage and glare barrage
8. Smokeout

II. TECHNIQUES OF BOMBING

Important to know these techniques in order to know some of the things that determine how camouflage works.

Nobody can say whether this region will be attacked, or when. If it is, the attack may perhaps come early in the morning. It is important for the success of camouflage to take into consideration the kind of shadow and lighting which will prevail at the probable hours of attack, and the different seasonal and weather conditions. It is not likely (one says with crossed fingers) that bombing will occur during those periods when weather is strongly adverse.

a. Area Bombing

Many planes dropping their bombs more or less at random over a designated area, criss-crossing and "strafing" the whole region. Resorted to when targets are highly concentrated; when the general neighborhood, but not the precise location, of a target is known; when good camouflage makes recognition difficult; when weather is not too favorable, etc. The Nazis use it for terrorism — "schrecklichkeit" — since it is indiscriminate in its destructiveness. It is very wasteful of material, and a large percentage of the bombs fall where they do little damage to important war activities. Ordinarily area bombing requires that the distances covered by the attackers are not too great. Area bombing is the "shot-gun" method.

b. Precision Bombing

Contrasted with (a) this is the "rifle" method. The attacking bombardier fixes his bombsight on a specific target and delivers a bomb on that target; he may do this a few times, but ordinarily his bomb-load is small.

Briefly, the precision bombardier wants to be pretty much on his exact course some 50 miles away. When he is about 10-15 miles away his course must be very accurate, leading directly to the target. About 6 miles away he must recognize his target in the bombsight and make preparations for the release of bombs; this point is known as "average target recognition," and is about 60 seconds away from the point of bomb release. About 4 miles from the target, and 35 seconds from the point of bomb release, is the "minimum target recognition" point; here the target must definitely be fixed in the bombsight and the bombsight set in motion. At the end of the 35 second period, the bomb is released. Note that the bombsight must be set in motion for the release of the bomb about 35 seconds before the bomb is delivered. It is the purpose of camouflage to make recognition tardy, uncertain, or difficult. Thus, if the bombsight is set in motion a second or two early, the bombs will fall short; if set in motion a second or two late, it will over-shoot the target. At 270 miles an hour these errors will be of the order of 400 feet per second. It must be noted also that camouflage, directed against precision bombing primarily, must be effective at the bombing angle — somewhere between 35° and 60°. (All figures here are qualified by height, speed, wind velocity, etc.) Some people feel that a bombing in this region will be of the precision variety.

c. Dive Bombing

A form of precision bombing, really. The plane itself is aimed at the target, dives from about 5,000 feet at an angle of about 70°, and about 1,000 to 1,500 feet from the target the bomb is released and the plane zooms upward. For really satisfactory results in either form of precision bombing the target must be clearly in the bombsight, and visible to the bombardier.

d. Hedge-hopping

The planes come in low, swoop up over the target, release their bombs, drop low again, and off. Has many advantages of protection for the attackers against ground defenses. However, camouflage could be very effective against such fast-moving and short-range attack.

e. Fire or incendiary bombing

Not really a technique of bombing, but another variety of area bombing. In this case, fire bombs are strewn more or less at random over a designated region, to fall wherever they will.

III. OBSERVATION

We camouflage against observation from the air (with the exception noted in (a).

a. Ground observation

Mostly in military usage; objects on the ground camouflaged against observers on the ground. On sea, camouflage of ships against ships or submarines. Ground observation includes, of course, direct and photographic observation, described below.

b. Aerial observation

1. Direct. In the long run the most important, since the bombardier must see the target with his own eyes and in his bombsight for the best results. Against this type of observation alone, the camouflage need not be so complete, theoretically, as against No. 2, below.

2. Photographic. The camera will reveal much that the human eye might miss; the photograph may be studied at leisure; comparison of photographs taken at different times will show up differences in the look of things.

a'. Panchromatic photography. Ordinary black and white photography with the familiar range of sensitivities to color and light.

b'. Color photography (Aerial). Not too satisfactory as yet, but still, may reveal important data.

c'. Infra-red photography. Valuable because infra-red "cuts through" haze, giving sharp detail from great heights. At the same time infra-red sensitive film responds strongly to infra-red rays reflected or transmitted to the film; this manifests itself in the finished photo as very light, or white, wherever infra-red reflectance was present. Chlorophyl, nature's green substance, reflects highly in infra-red; thus nature's greens appear whitish in infra-red photos. This is not true of all natural greens (for example, those in many coniferous trees). Thus it becomes important that an installation, camouflaged with green paint, and situated in natural greens, should be made to reflect infra-red rays in the same intensity and distribution as that of the surrounding greens. Pigments have been invented which will do this; at the same time they match exactly the natural colors, as seen by the eye.

d'. Stereo-photography: The principle of the old-fashioned stereoptican; gives an astonishing three-dimensional quality, and shows relative roundness and modelling. These tend to be flattenned out in ordinary aerial photos. Topographical differences of as little as three feet, and intervals of as little as one foot, can be detected in photos taken at great height, if viewed stereoscopically. Camoufleur must take this into consideration if he does not want his work undone, especially in military practice.

Primarily, however, camouflage in back-areas is directed against the personal observation of the attacking bombardier.

IV. HOW A BOMBARDIER LOCATES HIS TARGET

As the attacker nears his objective he ordinarily relies less on the traditional navigational aids, and picks up previously studied landmarks, reference marks and directional indications (the recent hoax in the East publicized the sort of marker or directional indications that might be used). A fairly satisfactory job of bombing may sometimes be done on a hidden target from landmarks alone.

Landmarks

Man-made:
Roads, railroads, bridges, viaducts, monuments, reservoirs, prominent structures of all sorts, etc.
Natural features:
Coastlines, rivers, cliffs, lakes, etc.
"Disciplined nature":
Gravel pits, golf courses, parks, cemeteries, parking lots, etc.

These stand out because of:

A. Shape and Bulk
The sheer size of landmarks and objectives often gives them away. Their contrasts in scale with their surroundings.

B. Shadows
Are often more important optically than the objective itself, e.g., the shadow of a bridge over a stream; towers and stacks throw bad shadows, etc.

C. Texture
Is tell-tale even at considerable heights: roofs, roads, packed earth are relatively smooth and highly reflective ordinarily; close-clipped turf, many fields, are less reflective, and appear darker; tall crops, scrub growth, trees, woods, appear quite dark. Each has its own tell-tale appearance from the air. Water varies considerably due to wind, flow, incidence of light.

D. Color
Is least important.

II. Stereo-photography: The principles of [illegible] stereoptical [illegible] three-dimensional quality, and shows relative [illegible] and [illegible] that would be flattened out in ordinary [illegible]. For [illegible] differences of as little as [illegible] as one foot, can be detected [illegible] great [illegible], if viewed stereoscopically. [illegible] and later [illegible] especially in military operations.

[illegible]

IV. HOW A [illegible] TARGET

As the [illegible] nears the objective he ordinarily relies less on the conventional [illegible] and more upon visually [illegible] reference [illegible] and direction [illegible] of [illegible] or directional indications that might be used. A fairly satisfactory job of bombing may sometimes be done on a [illegible] alone.

Landmarks

Man-made:
Roads, railroads, bridges, viaducts, monuments, reservoirs, prominent structures of all sorts, etc.
Natural features:
Coastlines, rivers, cliffs, lakes, etc.
"Unclassified [illegible]":
Gravel pits, golf courses, parks, cemeteries, parking lots, etc.

These stand out because of:

A. Shape and Size
The shape and size of landmarks and objects often gives them away. Their contrast in scale with their surroundings.

B. Shadows
Are often more important optically than the object itself, e.g., the shadow of a bridge over a stream; towers and stacks throw [illegible] shadows, etc.

C. Texture
Is tell-tale and of considerable help: roofs, roads, [illegible] which are relatively smooth and highly reflective, ordinarily; close-clipped turf, many fields, [illegible] and appear darker; tall crops, scrub growth, trees, woods, appear quite dark. Each has its own tell-tale appearance from the air. Water varies considerably due to wind, flow, incidence of light.

D. Color
Is least important.

V. THE DECISION TO CAMOUFLAGE RESTS ON:

A. The importance of the installation to the war effort, and the seriousness of its possible loss.
B. Vulnerability (how badly could it be damaged?)
C. Likelihood of attack (is it easy to attack?)
D. Value to enemy of the destruction of the objective.
E. Replaceability (would it be difficult to repair or replace?)
F. Possibility of sufficient success in concealment: its "camouflageability."
G. Proximity to natural and other landmarks (which are not concealable, and will betray.)
H. Cost of camouflage as compared to value of installation.
I. The extant of other forms of protection (fighter planes, anti-aircraft guns, barrage balloons, etc.)

These factors, though not necessarily in this order, indicate the considerations which lead to the decision to camouflage or not, and in what degree.

SECTION TWO: VISUAL PERCEPTION: THEORY

I. Since we are dealing with camouflage as it is directed against vision, we must momentarily examine the nature of visual perception. All things seen are seen by virtue of the fact that they emit or reflect light. Visual perception is dependent upon the quantity and quality of light. (Other factors, not to be discussed here, are neurological, psychological, biophysical, etc.)

Perception rests on data and inferences indicated below:

A. Size
Constant size: a man is so-and-so tall, no matter how small he appears to be in the distance.
Relative size: if the man appears small he must be far off;scale.
Comparative sizes of different familiar objects.

B. Shape and contour
Constant; and relative, as when a shape which we know to be spherical appears irregular because of shadow, obstructions to vision, etc.

C. Bulk and modelling
The volume and topography of the surface. Lack of bulk.
Indications of these in shading and shadows.

D. Proportion of parts

E. Structure or articulation
How the thing is put together.

F. Customary bearing or attitude

G. Apparent position in space
Near, far, in front of, behind, overlapping, convergence, etc.

H. Texture and reflectance
Rough, smooth, shiny, gnarled, bright, dull, matt, glistening, etc.

I. Contrast in value
Lighter than, darker than, surroundings.

J. Contrast in color
Hue, saturation, brightness; these in relation to surrounding conditions.

K. Context or setting
What "goes" with what: railroad sidings often "go" with factories; large paved areas with big installations.

L. Associations
What things have come to mean to us; what they suggest.

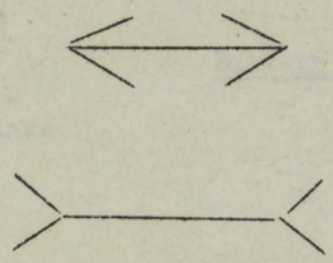
M. Attention and distraction
How long we may study a familiar or unfamiliar thing in order to "read" it correctly.

N. Surface markings or patterns
Flat, or in relief.

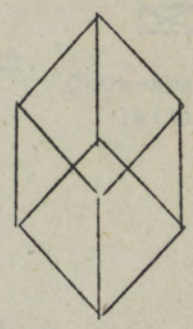
O. Shadows
Giving more information about the thing, sometimes, than any other consideration.

II. OPTICAL ILLUSIONS (The instability of visual impressions).

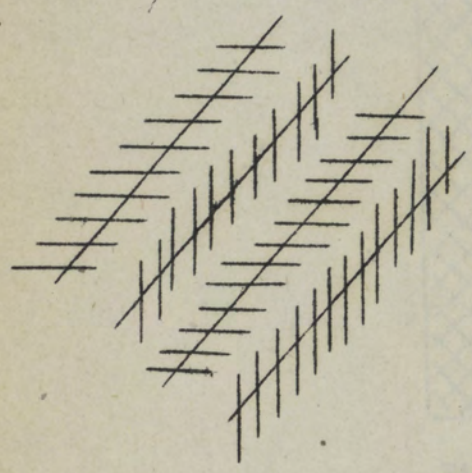
It is well known that the eye is very easily deceived; that visual impressions shift very easily, giving more than one verdict for the same evidence. Some examples are given here, and perhaps some applications in camouflage will suggest themselves.

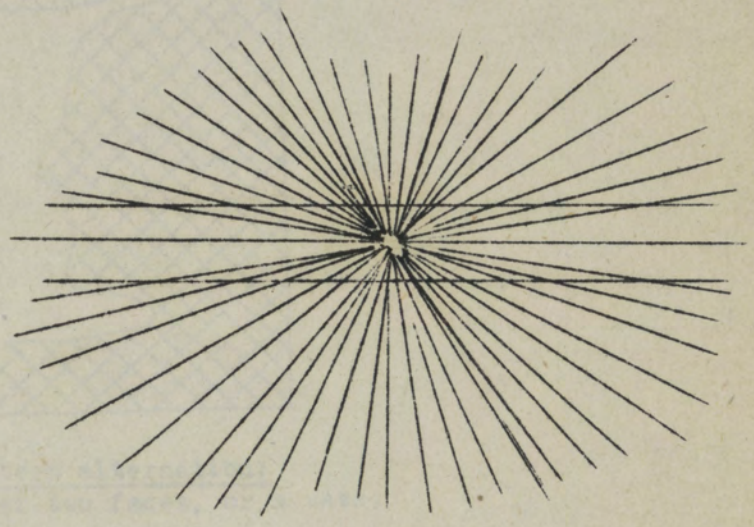


Lines of equal length appear unequal

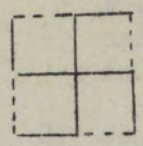


Reversible Cube

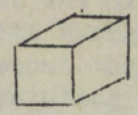


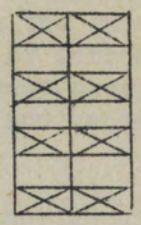


Parallel lines, which do not appear parallel



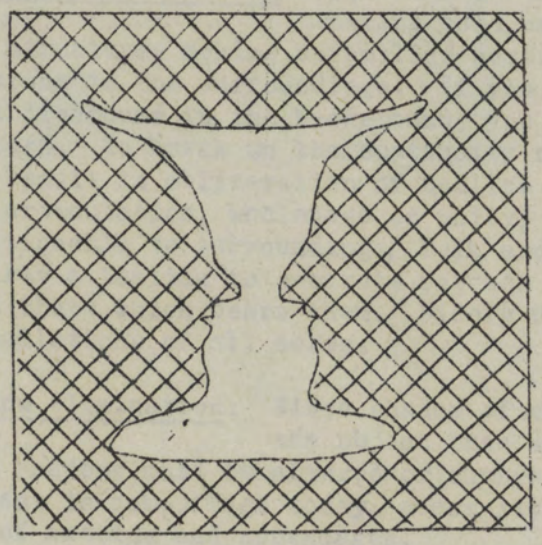
Swastika -
lost in square





Pattern neutralization

Cube-shape lost in
lattice pattern



Field and pattern alternation;
one may see either two faces, or a vase.

Toward the end of World War I, clevel use was made of geometrical optical illusions for marine camouflage. Certain principles, related to those illustrated here, were used in the creation of camouflage patterns for ships. These were very effective against surface observation; they created very misleading effects relative to apparent direction of the ship, apparent size and structure, apparent distance from the observer. This is not to be confused with "dazzle painting", which merely imposed a multi-colored jig-saw pattern on boats or guns. The practice referred to above, and lately revised in a somewhat modified form, was a scientific application of principles of geometrical optical illusion. It is also applied to tanks, gun carriers, and occasionally, to airplanes.

III. SOME OPTICAL PRINCIPLES ON WHICH CAMOUFLAGE IS BASED Following Cott's scheme (see page 2 for reference).

The connection between this item (III) and the above (I) and (II) is obvious; (III) being a specific application of (I) and (II).

A. CONCEALMENT

1. Color resemblance. To give the installation the same general color as its background or surroundings. A white sniper's suit in the snow; the Japanese have been using a green sniper's suit, painting faces and hands green, in South Pacific jungle warfare.

2. Countershading. To paint the topside dark and the underside light, in order to minimize the effect of modelling given by light falling on the topside, and shading underneath. This makes things appear much flatter, therefore harder to see. Combined with color resemblance, a substantial reduction in visibility results. Now used in the camouflage of airplanes, guns.

3. Disruptive patterning. To break up the familiar contours by making bold patterns which run across the structure, making unfamiliar sections, and joining some sections to the surroundings. If you have certain tones which will disappear in the background, you begin to lose the pattern. To break up the continuity of surfaces and shapes. May result in obliteration of outline and silhouette, structure and articulation, wholeness or unity, exact position in space, relationship to surroundings, bulk and modelling. Effect is to draw attention to separate patches or masses, and away from shape which bears them. Widely used in airplanes, ground installations of all sorts.

4. Shadow elimination. Since shadow often tells more about the object than apparent contour, the cast shadows must be altered or suppressed. A most important element in camouflage today, accomplished usually through use of netting and appendages.

B. ADVERTISEMENT

To attract attention elsewhere, deliberately, so that it is hard to study and concentrate on the thing to be hidden; to make a thing more conspicuous for certain reasons.

C. DISGUISE

Resemblance to, or imitation of, something else. Mimicry. Dummies and decoys.

SECTION THREE: CAMOUFLAGE METHODS; APPLICATIONS OF FOREGOING PRINCIPLES

I. TECHNIQUES

A. Siting

Most important in new construction is the location and adaptation to the site. Proper orientation to sun, so that cast shadow is at a minimum. Conformity with topographical contours in nature. Preservation of natural foliage and cover. Conformity with existing field patterns, or urban patterns. Existing patterns which are complex are easier to hide in than environments which are simple and plain. Avoid location in congested areas, so that bomb misses will not do great damage to dwellings or other plants.

B. Painting

1. Simple tone-down, reducing glaring contrasts with surroundings. Make installation retire in general color quality of the vicinity.
2. Pattern painting -- disruptive designs to destroy the optical continuity of the installation.
3. False shadows to disrupt shapes further.
4. Mimicry and illusionistic painting -- painting cottages, or trees, or fields, on large factory surfaces, or on dummies.

C. Projections, appendages, screens

To break up edges, contours, tell-tale shadows; to join together separate parts; to block vision. Vertical, horizontal, etc.

D. Disguise through use of local materials

Make installations look like city dump, natural growth, ruins, etc., through use of suitable materials characteristic of the vicinity.

E. Simulation through paint and/or textures

For instance, painted trees and crops, on airfields and runways.

F. Simulation through altered reflectance

As above. For instance, scarring the earth, burning or killing grass, directional cutting of grass, stimulating growth of grass, etc.

G. Netting, flat tops, drapes

One of the most important of all camouflage techniques. To present the desired appearance to the observer; to kill shadows, as on ridged or saw-tooth roofs; to cover large areas concealing what goes on underneath. Sometimes imitative painting on top of large netted areas creates the illusion of houses, roads, fields, etc., as they existed prior to the netting.

H. Dummies and decoys

The construction, or illusion, of false installations which look important enough to warrant bombing; or which repeat several times over an installation otherwise difficult to camouflage, thus confusing the attacker.

I. Planting

Trees, shrubs, and bushes can break up shadows, cover edges, break up shapes, make oblique observation difficult. Grass and plants cut down high reflectance. Grass or sod on flat roofs can be very effective in matching adjacent fields; vines and ivy blend well with background foliage.

J. Texturing

To make the installation reflect light in the same way as surroundings. Treatment of earth for desired texture; use of adhesives and granules, wood chips, cinders, bark, etc. Treatment of runways to simulate adjacent ground.

K. Altering ground level

To make high structures appear low.

L. Dispersion

Construction in smaller units; avoidance of formal and elaborately symmetrical plans, concentration, long unbroken structures, or regularity. This technique reduces likelihood of damage to a minumum, and makes some of the other techniques more successful.

M. Complete concealment

Crucial plants built underground, or in the side of hills.

N. Water problems

Use of floats, nets, water plants, scums and dusts, etc. to alter appearance and reflectance of water. Some of these techniques are very successful.

O. Camouflage discipline

This is not precisely a technique, but it is a major consideration. It means maintenance of camouflage and adaptation to season; above all, it means observance of rules and regulations imposed by the need to maintain effectiveness of camouflage, e.g., keeping to prescribed paths and roads, parking under cover, putting up with all the inconveniences that protective concealment may impose.

II. THE MATERIALS OF CAMOUFLAGE

These will vary somewhat according to locality, special preferences, and accumulated experience and research. The main categories include:

A. Paints and adhesives (a partial list)

Paint alone is not as important as some people suppose; it cannot eliminate shadows or flatten round bulks. Nevertheless, it is a basic material.

Casein or Protein paints.
Oleo-resinous emulsifiable paints.
Bituminous emulsions
  a. Non-pigmented adhesive (for use with texturing materials)
  b. Pigmented emulsion (for coloring stone, concrete, etc.)
Bituminous cut-backs (for stone, etc., shadows on earth, painting grass, etc.)
Oil paints (flat and dull. Nine standard camouflage colors. Ordinary commercial paint is not very infra-red reflecting, if at all. Approved camouflage colors must have the proper infra-red reflectance.)
Gasoline soluble paints.
Concrete paints (good for painting on metal).
Stains.

B. Texturing materials (a partial list)

Roofing and other mineral granules.
Sawdust and wood-chips, ground bark.
Cinders, fine slag.
Corn cob chips, dried silage.
Gravel, rock, slate granules, etc.

C. Natural and local materials (a partial list)

Green vegetation: grass, sod foliage, branches in leaf.
Dry vegetation.
Debris, sand, anything else characteristic of the given locale.

D. Nets, garnishes, drapes (a partial list)

Nets: for flat tops, sloping surfaces to reduce shadows, to alter appearance, or reflectance, or to conceal. Fish-net, chicken-wire, other wire netting. Visinets and shrimp net (small mesh), paper netting.

Garnishes: these are materials which are woven into some of the netting materials mentioned above. These garnishing materials must fit in well with the coloring and general character of the vicinity. They are painted or sprayed; sometimes they are woven with different patterns. Very often elaborate imitative painting is carried out on top of the netting; dummy roads are painted across the top, field patterns are simulated, dummy houses are constructed or painted, and so on. This is true mainly when large areas -- acres -- are netted over.

Osnaburg. A cheap sort of cotton canvas, cut into strips and colored in the suitable camouflage colors.

Steel wool. Rust-proofed, colored with camouflage paint, fastened to netting. May simulate different types of vegetation.

Glass wool. As above.

Asbestos wool, rock wool, have been tried.

Vegetable fibres.

Plant substances chemically treated and extruded as fibers.

Chicken feathers. Stuck on to netting with adhesives.

Tufts of tall grass, pine needles, etc. stuck into netting. Cut -- and often renewed-branches laid across netting.

Drapes: small-mesh netting, suitably colored, thoughtfully thrown across objects, like a plane, will break contours, shadows, and bulk, to some extent.

E. Plant materials

See item (C). Includes planting, forcing growth, holding back growth, trimming and directional cutting, etc. Has the great advantage that seasonal changes are automatically taken care of. Disrupts pattern and vision, as suggested inSection Three, Item I - Camouflage Techniques. Cut trees may be mounted upright on roofs (especially evergreens). Trees, properly planted in relation to installations, provide one of the best forms of obscuration, and in addition add to beauty of surroundings.

III. DEGREES OF CAMOUFLAGE INTENSIVENESS

When the decision is made to camouflage, the extent and degree is determined by consideration indicated in Section One, Item V. Roughly, this enumeration lists what might be done, depending upon the urgency of the situation and the "camouflageability":

1. Tone-down and paint-down. A general dulling-down of all surfaces and contrasts, and the approximation to the general coloration and tone of the surroundings.

2. Some disruptive or abstract imitative pattern painting, and some breaking up of shapes with netting, or flaps; general tone-down as above; some false shadows.

3. Extensive disruptive pattern painting, illusionistic painting (mimicry) of nearby features, false forms, netting, contour and shadow disruption and alimination, texturing, planting, perhaps even relocation of some items, e.g. driveways, sidings.

4. Complete concealment under elaborate superstructures, which exactly imitate the patterns of the vicinity; burying underground, in hills, in buildings of another sort; construction of dummies and decoys.

IV. CONSTRUCTION AND MAINTENANCE PROBLEMS

The project must be constructed so that the newly added loads will be well within existing factors of safety, or in other ways made to conform to safety needs. The loads and stresses due to wind, rain and moisture, snow, must be calculated; sagging and stretching, etc.

While traffic and circulation will probably suffer to some extent in elaborate camouflage projects, care must be taken to make the design in a way which will interfere as little as possible with existing procedures.

Maintenance is important; nets must not be allowed to sag, designs must not be allowed to become obliterated through dirt, flaps must not be broken off, cut foliage must be replaced, etc. Seasonal replacement is necessary in many instances.

Cost limits are determined according to certain formulas, relative in general to cost of the installation, and the chances of destructive attack (See Section One, Item V). The camoufleur must be resourceful in the use of local materials; he must, as much as possible, steer clear of priorities and restricted materials.

V. OTHER FORMS OF PROTECTIVE CONCEALMENT

A. SMOKEOUT

This consists of putting a haze or covering of smoke over an objective or an area. It must be extensive enough so that the target is hidden "somewhere" under the covering.

Smoke may be the result of combustion, chemical reactions other than combustion, and vaporization. Chemical smokes are too costly for large area use, and some of the most effedtive may be harmful to materials, and require a good deal of handling. Vaporization offers interesting possibilities for large areas. Combustion is easiest to have, since industrial communities like Cleveland can make a good deal of smoke without trying very hard. This region is close to great quantities of high-volatile fuel; oil is used pretty widely. Through deliberately poor combustion, fires may be made to give off quantities of smoke. Stacks emitting this smoke can be planned in such a way that with any usual wind, conditions will make it possible to have fair coverage.

The water problem is difficult in smoke coverage, but not impossible; one might devise smoke-barges; smoke bombs or rockets have been suggested, etc. A good possibility is the smoke-laying airplane. The present and recognizable boundaries of the city and the water front should be obscured under the haze of smoke, thus making it difficult for the attacker to take any bearing near the critical zone.

Smoke has the advantages of: great expanse of coverage in a city like Cleveland, where stacks are widely scattered; its obscuring power is effective night or day; the "protection-cost" ratio is comparatively small; it is felt that a city-wide covering can be

laid between the time of the first alert and the arrival of bombers. Smoke is widely used on both sides in Europe, and some of the most publicized targets of the war have escaped direct hits largely because they have been under the cover of smoke.

B. BLACKOUT

This is really another camouflage technique, for it makes the target harder to find from a distance, and it makes it hard to find specific objectives within the target area. Blackout must be complete to be effective, since the presence of only a few lights or reflections will attract attention, and may provide a clue as to position. By turning out all lights, or reducing their output to extremely low intensities, the tell-tale street-lighting pattern (which makes the layout of a city more conspicuous at night than it is in the daytime) is obliterated, as is also the tell-tale "glow pattern", (by which one may tell congested or otherwise distinctive localities). Distinctions between land and water are very difficult to note under complete blackout. However, moonlight renders blackout ineffective: it not only illuminates the city to a marked degree, but it also reflects from windows, skylights, reservoirs, rivers, and so on; flares, of course, completely undo blackout concealment.

All establishments must take measures to conceal their illumination completely (by use of light-locks, or by painting, screening, or covering their windows); or they must use only the prescribed extremely low intensities of light; or they must extinguish their lights entirely. Blackout specifications allow a light output of no more than 3 lumens per light unit, used very sparingly (3 lumens is about the amount of light which would be given off by an ordinary tallow candle if three-quarters of it were blocked off). Out-of-doors specifications permit light intensities of not more than .0006 footcandle on the street (this is about twice or three times that provided by starlight on a clear, moonless night). Blue lights should not be used — they are more conspicuous than red or white.

Factories and steel mills have been ordered to devise methods of obscuring light from industrial processes.

Luminescent substances — phosphorescent, fluorescent, and radioactive — are sometimes used for signs, markers, and guidds under blackout conditions.

C. LIGHT CAMOUFLAGE

Another type of protective concealment intended for large areas. The variations all use light in one way or another. The first two are thought of in conjunction with blackout, and the third is a partial blackout and partial dimout. Some people refer to them all as "Light-up", as opposed to blackout.

1. Glare barrage

Lights mounted high, and directed upward; the lights being of sufficient brightness and output that an effect of glare is produced on the retinas of the observer's eyes. This makes it

difficult, if not impossible, for him to see what lies underneath the lights. A common error is to suppose that in order to secure this glare effect the observer must be "blinded," as by automobile headlights at night. Glare effect may obtain even though the feeling of "blindness" is not present.

Glare may be used in conjunction with,

2. Pattern of Confusion

Glare sources or other light sources could be arranged in an arbitrary pattern which has no relationship with the layout or pattern of the community, ignoring the street pattern, valleys, parks, shore lines, and city limits. Looking down on such a pattern it would be impossible to take bearings from the visible pattern, or even to know exactly where, over the city, the observer was. Such confusion patterns could possibly be changed at will.

3. Pattern of Sameness

When the pattern of a city is sufficiently regular and grid like, it might be possible to impose on that community a very monotonous pattern of street lighting. Since everywhere would be the same monotonous pattern, points of reference would be pretty well eliminated. The differences in intensity of light-glow are cut down so that there is the same low intensity of light in the whole region. Once again, it would be hard to locate oneself exactly. In this case, we would probably have blackout of everything except the dimout in the streets.

4. Combinations of the above

Would probably be very effective. A smokeout and simple dimming-down of lights might be excellent, and have the advantage that it would not force people to live in pitch dark during raids.

D. EXPERIMENTAL TECHNIQUES. THE "LUNATIC FRINGE"

Camouflage, as old as it is, is still young in a scientific way. Much remains to be done in all phases of the craft. Scientific principles and methods must be brought to bear; modern technology must be used. The enormous scale of civilian protective concealment suggests that new techniques for all-over coverage must be experimented with. The psychology of perception must be studied with especial reference to the problem of camouflage.

Effects of movement are suggested; special effects through flares, rockets and other distracting agencies; and many other ideas are advanced. While many of these suggestions are worth serious consideration, it becomes clear that many others are only "screwball" notions coming from the "lunatic fringe." However, even in preposterous theories there may be the germ of a valuable technique.

Above all, camouflage and protective concealment must be considered from the very beginning in all new construction. It is better to do the job of concealment right, from the beginning, than to have to expend great sums doing a patch job later on. In addition, it will be seen that the demands of good concealment for protection in the original planning are to a large extent exactly what progressive city-planners have been looking for these many years.

CAMOUFLAGE MAXIMS

1. To disrupt a shape or an object, make sure that your disruptive pattern interferes with the visual continuity and articulation of the pattern as it originally existed (e.g., by making disruptive patterns extend over edges and corners; joining sections of wall and ground, etc.)

2. Disruptive patterns should be large and fairly bold -- enough so that differentiation is not lost at bombing or attack distance.

3. In general, avoid the symmetrical, the regular, the exact repeat . (e.g., do not treat all four corners of a building in the same way).

4. The design of disruptive patterns ideally should follow the chafacter and contrasts of the masses in the vicinity (e.g., if the patterns of the masses are large, and the contrasts very strong, the disruptive patterns must be large, the contrasts strong). The character of the existing shape - and contrast-patterns may be determined to a large extent by the old-fashioned artistic method of squinting through nearly closed eyes; one may also learn to "abstract" the general character of the masses and values, as Cezanne and the early Cubists did.

5. The basic "compositional" lines on which a disruptive pattern is laid should avoid regular intervals (e.g., do not divide a roof in half diagonally, and then draw three equidistant perpendiculars to the diagonal; do not plan disruption of a plane on diagonals drawn from the corners of the wings).

6. Two or three colors are ordinarily sufficient in a disruptive scheme; one should be black, ordinarily. The individual colors, and the general color effect should be an approximation to, or "abstraction" of, the general color qualities of the vicinity.

7. Generally speaking, topsides should be darker, undersides lighter.

8. Absorb shadows into black pattern painting wherever possible; you cannot paint black as black as a deep shadow. Attempts to disrupt a natural shadow area with paint are usually ineffective.

9. In simulating or imitating shadow effects, remember the position of the sun.

10. False superstructures, screens, and wings, may be built to cast deceptive or misleading shadows, or to alter the tell-tale character of the existing shadow pattern.

11. Tone is more important than color alone, especially at a distance. (Tone is a combination of color, value, reflectance, atmospheric effect, etc. Of all these elements, color is definitely not the most important in simulating the general effect at a distance).

12. Texture and reflectance are vital considerations -- how much light is reflected, and what quality. (A tree appears almost black from a considerable height, because its reflection factor is low; still it reflects a different quality of light than another equally low reflectance, for example a black-top road. Therefore in simulating trees with paint, let reflection factor plus quality be your guide, but not the immediate color of the tree).

13. Nettings, screens, or appendages must be used to "break" the edges of buildings; or to join separate units together at certain places, by bridging gaps. Foliage may be used for these purposes in the field.

14. Camouflage against air attack is designed mainly against oblique observation.

15. Siting is most important: selection of a position which favors easy visual approximation to the surroundings.

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A SELECTED AND ANNOTATED BIBLIOGRAPHY ON CAMOUFLAGE

*Breckenridge, Robert P., MODERN CAMOUFLAGE. New York: Farrar and Rinehart, 1942

The most recent, complete and authoritative book on the subject, by one of the country's leading experts. The writer, a Major in the Corps of Engineers, is stationed at Fort Belvoir, Virginia, the main center of the Army's camouflage work. Much broader in its scope than any other book on the market, surveying theory, techniques, materials and construction problems in camouflage; discusses the relation of camouflage design to bombing tactics; siting and planning in new construction; the use of plant materials; the use of decoys; the making of models; blackout, smokeout, and other types of protective concealment. The book is profusely illustrated with many new photographs, and contains numerous tables, lists and diagrams.

Chesney, C.H.R., THE ART OF CAMOUFLAGE. London: Robert Hale, Ltd., 1941

Twenty-eight pages on camouflage in nature are supplied by J. Huddlestone, briefly indicating the scope and wealth of protective measures in the animal world. Lt. Col. Chesney, of the British Army, reviews camouflage experiences in the world war of 1914-18; provides some very useful observations on the principles and execution of modern, civil, military and naval camouflage. A section of the book is given to the analysis of examples of "strategic" camouflage, or "the camouflage of military intention". An appendix provides a stimulating exchange of ideas relative to camouflage and city planning.

*Cott, Hugh B., ADAPTIVE COLORATION IN ANIMALS. N.Y., Oxford University Press, 1941

Unquestionably the most scholarly and authoritative work on protective concealment and optical deception in nature. Sets forth the optical principles which are basic to all camouflage work, and illustrates these principles and their applications in the animal world. Almost all forms of camouflage technique are thus presented, and their applications to the needs of the day are easily inferred. Beautifully illustrated with drawings and photographs by the author. Should be considered as a basic text in all camouflage study.

Glover, C.W., CIVIL DEFENSE. Brooklyn: Chemical Publishing Co., 1941 Chapter XIV: Camouflage, pp. 555-608

A brief, though not well organized review of some major considerations in camouflage. Owes much to Cott for optical principles; discusses basic camouflage techniques and procedures, materials; some fine material on blackout methods and protective construction.

Kipling, Rudyard, HOW THE LEOPARD GOT HIS SPOTS. Garden City: Garden City Publishing Co., 1942

This delightful yarn seems almost as though it might have been written for the purpose of popularizing camouflage. A better exposition of the essential optical considerations can hardly be found. The sprightly drawings in this edition, by F. Rojankovsky, add to the charm of the exposition.

*Luckiesh, M., VISUAL ILLUSIONS, THEIR CAUSES, CHARACTERISTICS AND APPLICATIONS. New York: D. Van Nostrand Co., 1922. Chap. XV; Camouflage

Still valuable for present-day problems; this chapter was written by one of the pioneers in helping to put camouflage on a scientific basis. Discusses camouflage on land, water and in the air; special reference to problems of visibility. In general, the study of visual illusions may lead to valuable camouflage ideas.

Luckiesh, M., and Moss, F.K., THE SCIENCE OF SEEING. New York: D. Van Nostrand Co., 1937

An excellent book, which ranges widely over the field of vision, visibility, and light. Much of it is too technical for the lay reader; on the other hand, the lay reader will find a great many answers to questions dealing with sight and perception. It is an important book for anyone seriously interested in the study of camouflage.

Office of Civilian Defense, BLACKOUTS. Washington, D.C., 1941

A summary of blackout practice, very good as far as it goes, but owing too much to British problems and their solutions. Is in the process of revision.

Office of Civilian Defense, CIVILIAN DEFENSE - PROTECTIVE CONCEALMENT. Washington, D.C., 1942

An excellent survey of the field of camouflage practice, profusely illustrated, and containing many annotated lists of camouflage materials and other practical data. Much of recent writing on camouflage is derived from this source.

Sloane, Eric, CAMOUFLAGE SIMPLIFIED. N.Y., Devin-Adair Co., 1942

A useful, but very generalized survey of the field. Particularly good for the many pages of sketches which illustrate principles, problems, and methods. The drawings are gay and stimulating, even though one may occasionally disagree with the generalization. The teacher will find it a very helpful book, since it is a graphic rather than a strictly verbal presentation of an unfamiliar visual field.

U.S. War Department, CAMOUFLAGE. Engineer Field Manual, FM 5-20, 1940

Practice, materials and methods, as related to military needs. A very useful handbook, particularly valuable for its many detailed illustrations of procedure in the field.

*Wittman, Konrad, INDUSTRIAL CAMOUFLAGE MANUAL. N.Y., Reinhold Pub. Corp., 1942

"Represents many of the experiments and experiences that have developed in the classrooms and camouflage laboratory at Pratt Institute." Emphasizes the practical aspects of camouflage design as applied to industrial and civilian problems. Special emphasis is given to soundness of construction, to thoughtful and economical planning. These are illustrated by detailed examples, work sheets, cost estimating data. Profusely illustrated with good drawings and photographs, although the latter are not well reproduced. The book takes its place as a standard text.

Pamphlet

Great Britain, Stationery Office, CAMOUFLAGE OF LARGE INSTALLATIONS. Air Raid Precautions Handbook, number 11, 1939

A very useful, but very brief discussion of some of the standard techniques in civilian camouflage. Interesting for comparison of some of its views with American ideas.

Articles

*"Camouflage" Architectural Forum (New York), January 1942, pp. 14-25

An important summary of the most authoritative thought on the subject. It covers the fields of protective concealment, blackout, protective construction brilliantly, even if in a somewhat generalized fashion. A wealth of excellent illustrative material is supplied. It has become a "classic" in the field.

Dyer, Carlos, "The Role of the Artist in Camouflage" (in) BRITAIN AT WAR. N.Y. Museum of Modern Art, 1941, pp. 90-94

A good, but very generalized presentation of some fundamentals. Apparently owes much to Cott.

Fox, Milton S., "Camouflage and the Artist" Magazine of Art. Washington, April, 1942, p. 136

Discusses the customary training of the artist and its relation to the needs of camouflage. Offers a listing of skills and knowledges with which the camouflage specialist should have some familiarity or collaboration.

Hecht, Selig, "Seeing in a Blackout" HARPER'S MAGAZINE, New York, July, 1942, p. 160

An excellent popularization of matters related to visibility in general, and night visibility in particular. Absolutely essential reading for the serious student. Specifically applicable to blackout, but rich in suggestions of camouflage in general. The author is one of the country's outstanding experts on the subject of vision.

Saint-Gaudens, Homer, "We're Men of the Fantasy Forces" CHRISTIAN SCIENCE Monitor Magazine, Boston, June 21, 1941, p. 6

A witty article by one of the pioneers of American camouflage, now a Colonel in charge of camouflage. Here is set forth what camouflage is, both in the military and civilian realms; what the Army considers good prospects for camouflage work; and what camouflage work in the Army is like.

*The books that are starred are recommended for your library collection and should be secured as early as possible in schools where camouflage is being taught.